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National Defense Center for Energy and Environment

Cadmium and Hexavalent Chromium Free Electrical Connectors: A Synergistic Approach

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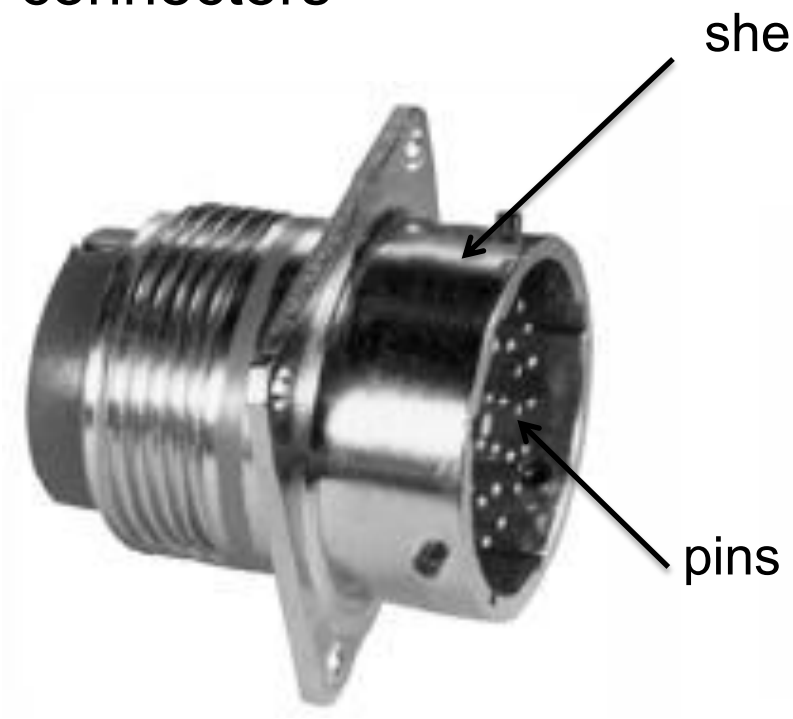
Presentation Outline

- Background
- Overview
- Identification of Army's Electrical Connector Requirements
- Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives
- Development of Test Plan
- Status and Future Activities
- Summary

Background

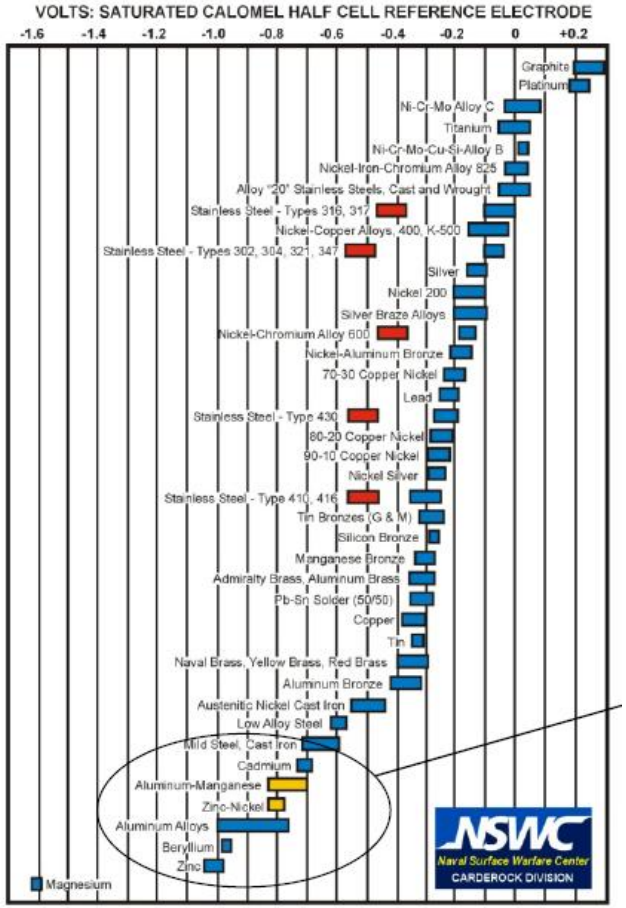
- Focus on shell coatings of military grade electrical connectors



- Receptacle (wall mounting)
- Plug (straight)

Background (continued)

- Shells currently coated with cadmium plating and hexavalent chromium topcoat
  - Imparts numerous engineering properties in synergistic fashion
    - Corrosion resistance
    - Ease of manufacturability
    - Electrical conductivity
    - Electromagnetic compatibility
    - Inhibition of algae growth
    - Lubricity
    - Repairability
    - Shock resistance
    - Solderability
    - Temperature resistance
    - Vibration resistance



Background (continued)

- Current and emerging regulations require consideration of alternative coating system
  - United States (U.S)
    - Executive Order (EO) 13423, S*trengthening Federal Environmental, Energy, and Transportation Management*
      - Requires Government agencies to reduce quantity of toxic and hazardous chemicals and materials acquired, used, or disposed
    - Cadmium regulated as Hazardous Substance, Hazardous Air Pollutant, Hazardous Waste, Toxic Chemical, and Priority Pollutant (Clean Water Act)
    - Restrictions from
      - Occupational Safety and Health Administration
      - Environmental Protection Agency
  - European Union
    - U.S. military systems exempt BUT could govern part availability in near future
    - Restriction of Hazardous Substances Directive
    - Waste Electrical and Electronic Equipment

Overview

- Purpose
  - Selection and testing of alternative coatings for electrical connectors used in U.S. Army ground systems
- Goals
  - Compliance with EO 13423
  - Compliance with other current and emerging regulations
  - Reduction of total life cycle costs of connector shell coating systems

Identification of Army's Electrical Connector Requirements

- Part numbers provided by TARDEC for four weapons systems
- Databases employed to obtain
  - Drawings (as available)
  - Procurement specification (as available)
  - Shell coating (cadmium, electroless nickel [EN], etc.)
  - Quantities procured (and dates)

Identification of Army's Electrical Connector Requirements (continued)

- Analysis – most commonly used connector types, by spec

CHAMPION: MIL-DTL-38999/26, class W connectors

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives

- Past Work to Demonstrate Alternatives
  - NDCEE
  - Strategic Environmental Research and Development Program (SERDP)
  - Environmental Security Technology Certification Program (ESTCP)
  - Joint Group on Pollution Prevention (JG-PP)
  - Joint Cadmium Alternatives Team (JCAT)
  - Defense Logistics Agency (DLA)
  - Concurrent Technologies Corporation (*CTC*)
  - Electrical Connector Manufacturers

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Findings - Viable Alternatives to Cadmium
  - Advanced Materials
  - Aluminum-Manganese Molten Salt Bath
  - Aluminum Deposited Through Chemical Vapor Deposition
  - Electrodeposited Aluminum (AlumiPlate®)
  - Electroplated Tin-Zinc (SnZn)
  - Electroplated Zinc-Cobalt (ZnCo)
  - Electroplated Zinc-Nickel (ZnNi)
  - Aluminum Deposited Through Ion Vapor Deposition
  - Metal-Filled Paints and Ceramics
  - Sputtered Aluminum

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Findings - Viable Alternatives to Hexavalent Chromium Topcoats
  - Trivalent chromium processes
  - Non-chromate processes
- *INITIAL* most promising cadmium alternatives for electrical connector applications
  - Electrodeposited Aluminum (AlumiPlate®)
  - Electroplated ZnCo
  - Electroplated ZnNi
- All three already approved for use on MIL-DTL-38999 connectors (*at least at first…..*)

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- ZnCo removed from consideration
  - Questionable corrosion resistance, especially at high temperatures
  - Removed from MIL-DTL-38999
- SnZn added
  - Based on some previous promising results
  - Client requested non-nickel candidate
- Also added two types of EN-polytetrafluoroethylene (PTFE) processes
  - Already approved for use on MIL-DTL-38999 connectors
  - Do not require topcoat

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Data Gap Analysis
  - Electrodeposited Aluminum (AlumiPlate®)
    - Approved for MIL-DTL-38999 (and MIL-DTL-5015)
    - Cyclic corrosion testing not done
    - Some further durability testing would be useful
    - Other gaps identified but may be filled with 38999 qualification testing

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Data Gap Analysis (cont.)
  - Electroplated ZnNi
    - Approved for MIL-DTL-38999 (and MIL-DTL-5015)
    - Relatively mature process – lots of general data exists
    - Cyclic corrosion, durability, electrical and mechanical data are gaps
    - Dezincification has been an issue in past studies
  - Electroplated SnZn
    - *No approval for MIL-DTL-38999*
    - Prior data somewhat inconsistent
      - Older formulations did not yield consistent alloy composition
      - Newer formulations may have alleviated issue

Review of Previous Efforts to Identify Cadmium/Hexavalent Chromium Alternatives (continued)

- Data Gap Analysis (cont.)
  - Composite EN (with PTFE)
    - Approved for MIL-DTL-38999
    - Currently undergoing qualification testing (manufacturers)
    - Cyclic testing, other important parameters outside of 38999 testing not being considered
    - Galvanic corrosion resistance questionable

Development of Test Plan

- Substrates, coatings, post-treatments
  - Candidate connector: MIL-DTL-38999 Series III Class W
    - Also test panels as available and needed
  - One substrate - 6061 aluminum
  - Control: cadmium with hexavalent chromium
  - Five cadmium alternatives
    - Electroplated aluminum (AlumiPlate®)
    - Electroplated ZnNi
    - Electroplated SnZn
    - Composite EN (two types)
  - Two hexavalent chromium alternative post treatments
    - Trivalent chromium
    - Non-chromate post-treatment (as available)

Development of Test Plan (continued)

- Proposed tests – Phase 1 (testing as specified under MIL-DTL-38999)
  - Corrosion, Salt Spray
  - Electromagnetic Compatibility/Electromagnetic Interference Effectiveness
  - Fluid Resistance
  - High Temperature Resistance
  - Mating and Unmating Forces
  - Shell to Shell Conductivity

Development of Test Plan (continued)

- Proposed tests - Phase 2 (testing not specified under MIL-DTL-38999 but important to Army)
  - Corrosion, Cyclic
  - Corrosion, Scribed with Primer and Topcoat
  - Corrosion, Sulfur Dioxide
  - Durability in Humidity
  - Galvanic Corrosion Resistance
  - Lubricity
  - Wear/Handling

Status and Future Activities

Procure test specimens	**April 2009**
Initiate testing	**April 2009**
Draft test report and submit	March 2010
Final report	May 2010

Summary

- Current and future environmental regulations will restrict the use of cadmium and hexavalent chromium on electrical connector shells
- To meet this need, this effort has
  - Identified the most commonly used electrical connector design in the inventory (based on data sets provided)
  - Identified five promising candidates to replace cadmium
  - Identified two promising candidates to replace hexavalent chromium
  - Developed a test plan to assess candidate performance for this application
- Specimen procurement and testing is currently underway

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Questions?